rainfall occurring within large areas of light and moderate rains. The best examples are found in the Gulf States and may be looked for in practically all seasons, although more common in the cold than in the warm season. This uneven distribution is common to both tropical and extra-tropical cyclones.

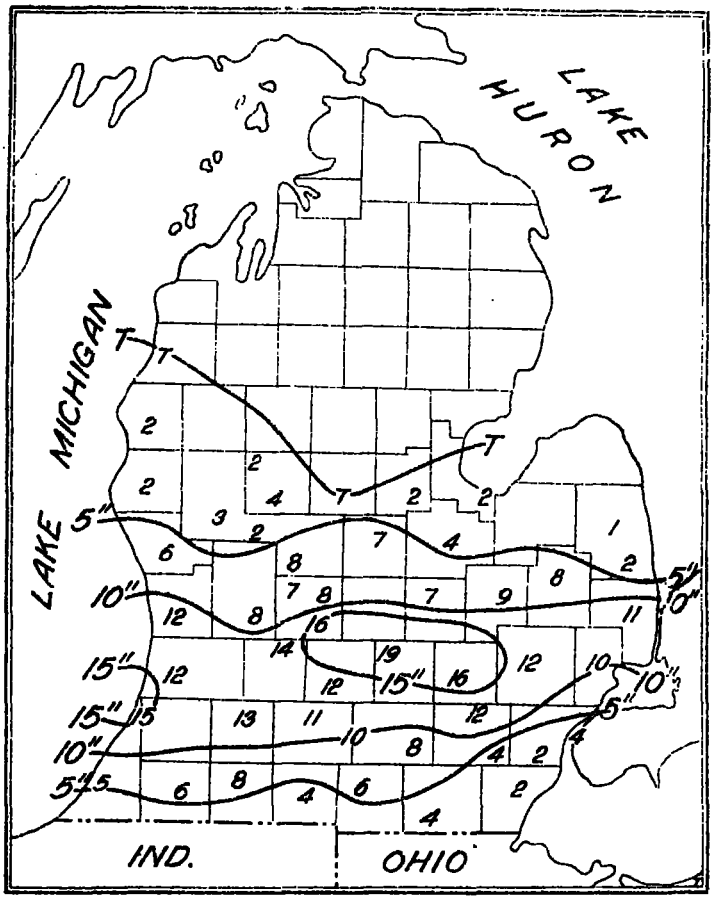

FIG. 1.—Snowfall in lower Michigan.

The source of the moisture is, of course, easy to fix, but the cause of the uneven distribution is not so easy to explain. It can not be due to surface relief because along the Gulf coast there is no surface relief worth mentioning.

In the absence of cloud or pilot-balloon observations it is not possible to determine the direction of the free-air winds over the regions of heavy rainfall, but there is every reason to believe that they are from the Gulf. In the cold season the air temperature at 3 km. level may be, and probably is, higher over the Gulf than it is over the adjacent continental area at the same level. The warmer air would then override the colder air and thus general precipitation would result. But would this be the case in tropical cyclones in which excellent examples of irregular distribution of precipitation may be found? Nothing is known of the temperature distribution in tropical cyclones. It would therefore be hazardous to place them in the same category with extra-tropical cyclones.

In the case discussed by Mr. Seeley, pilot-ballon observations made in the afternoon of the day before the snow storm show that southerly winds prevailed up to 3 km. and higher over a large area extending from Texas northeastward to the Great Lakes. That this presumably warm current from the southwest was underrun by a cold northerly current having its origin in the Lake Superior region appears to be the explanation of the heavy snowfall over Lower Michigan as shown in figure.

TORNADOES OF NOVEMBER 17, 1921, IN ARKANSAS.

By W. C. HICKMON, Observer.

[Weather Bureau, Little Rock, Ark., Dec. 9, 1921.]

SYNOPSIS.

Two tornadoes occurred in Arkansas during the late afternoon and evening of November 17, 1921, in which 11 people were killed, 39 or more injured, and nearly $20,000 worth of property destroyed. The first tornado occurred in southern Polk County and followed a west-east course; the other, starting in Clark County, moved northeastward across Hot Springs County into the southeast edge of Garland County. Both were very destructive when touching the earth; fortunately the funnel cloud seems not to have been in contact with the earth at all times, but lifted from place to place.

Preceding and attending weather.—The morning weather map of November 17 showed low pressure covering the Mississippi Valley and the Southwest, with the principal centers over Illinois and northeastern Arizona; high pressure overlay the Canadian maritime provinces and the northwestern border. The horizontal temperature gradient was steep from Kansas to Arkansas and Texas. In the evening the map showed the Arizona LOW to have increased in intensity. It was centered over New Mexico, with a trough extending northeastward across Arkansas to the Lakes, the HIGH in the Northwest moving in from the North Pacific. The temperature gradient continued steep. The pressure distribution, the marked difference in temperature over a small area of the country, and the location of the trough, all combined, made a condition favorable for the formation of tornadoes in Arkansas.

Probably two tornadoes.—While it is not absolutely certain that there were two tornadoes in Arkansas during the afternoon and evening of November 17, the fact that the first damage occurred in Polk County near 5:00 p. m. and the other did not occur until 8:30 p. m. leads us to believe that the two were separate storms. No trace of a destructive storm was found between southern Polk County and Clark County, so the two are mentioned separately.

The Polk County tornado.—The first and only serious damage done by the tornado in Polk County occurred about 1 mile west of Wicks when the home of R. E. Weems was totally destroyed and its eight occupants killed, their bodies being strewn along the storm's path, one being fully one-half mile from the place where the house stood.

Clark, Hot Springs, Garland County tornado.—Starting in sec. 31, Twp. 6 S., R. 20 W., in Clark County, and moving in a northeastward direction over a path varying in width from one-fourth to three-fourths mile, another tornado occurred which killed three people, injured 37, and did considerable property damage.

This tornado did not have a complete path from the lumber camp near De Gray to Lonsdale, but the direction of its movement and the time of its occurrence indicate that it was one and the same storm. Like the one in Polk County, the funnel-shaped cloud touched the earth only occasionally, but left destruction wherever it touched.

The Garysonia Lumber Co.'s logging camp, near De Gray, Clark County, was struck about 8:30 p. m. and was torn to shreds by the storm's fury, only splintered timbers remaining of the shacks and boarding cars in which the lumbermen and their families lived. In this

camp 1 woman was killed and 30 or more people were injured. It is estimated that 2,000,000 feet of timber was blown down, of which at least a third will be a total loss.

An unusual feature of the storm noted in this section was the absence of rain during its passage. A great glow lighted up the sky as the storm approached, and heavy hail was reported to the northwestward, but with the storm itself there was no precipitation.

Near Magnet Cove, Hot Springs County, one man was killed and four other members of his family were injured. In this neighborhood the storm cut a swath nearly a mile wide, twisting the timber and doing much damage to homes and other buildings. A little farther northeastward in Garland County another life was lost, this being the last loss of life reported.

Two years ago the Magnet Cove community was visited by a heavy wind, and this tornado seems to have followed almost the exact path made two years ago.

Heavy precipitation.—The passing of the LOW in which these tornadoes occurred brought excessive rains in Arkansas the 16th, 17th, 18th, and 19th.

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GREAT ICE STORM OF NOVEMBER 26–29 IN MASSACHUSETTS.

A shallow barometric depression (30.10 inches) developed during the night of the 26th–27th over the Atlantic directly south of Nantucket. This depression was formed in a bend of the isobar of 30.20 inches surrounding an anticyclone (30.50 inches) central over the mouth of the St. Lawrence. The gradients were therefore for northeast to north winds over New England, with rain and snow, depending upon the temperature. The northern HIGH gave way somewhat during the 27th, and by the morning of the 28th a large cyclone with central pressure 29.50 inches in southwestern Virginia occupied practically the whole of the New England and Middle Atlantic States and the western portion of the Canadian maritime provinces. By this time the snow of the first depression had changed to rain, which was general from Virginia to the Maine coast, snow falling only in the interior of Maine. The Virginia cyclone moved northeastward to the Atlantic south of New England by the morning of the 29th, and continued in a course to the northeast over the Atlantic. So much for the weather maps during the storm period. The following is quoted from a letter to the editor from Mr. Royal Robbins, Boston, Mass.:

> The storm caused a snowfall of over 2 feet in northern New England, and heavy rain with some snow in the southern portion of New England. Over an area of perhaps 3,600 square miles, 60 miles west and north from Boston, this heavy rain froze as it fell for parts of three days, resulting in the most severe ice storm within living memory. Rain fell for many hours, with a temperature of 26° (F.) and a total precipitation of more than 3 inches of rain.
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> Over this large area, chiefly in northeastern Massachusetts, where the rain froze as it fell, the damage probably exceeded that of any storm on record in the same territory. The loss to telegraph, telephone, and electric lighting companies is estimated at over 5 million dollars, while more than 100,000 trees were ruined. The value of the latter is difficult to compute, but would probably reach 5 or 10 million dollars more. The loss of this great number of beautiful trees in cities and towns is irreparable.
>
> While several gales occurred off the coast, the winds in the ice area did not exceed 30 miles per hour, so that the actual weight of ice was the chief cause of the great damage. The weight on the wires is said to have been about 2 tons between telegraph poles, 2,700 of which poles fell on one railroad in the 60 miles immediately west of Boston. The area of destruction was bounded on the north by the region where the precipitation was entirely snow; and on the south and west by the region where the rain did not freeze.

Dr. C. F. Brooks and Mr. G. F. Howe, writing in the *Bulletin of the American Meteorological Society*, give the following account of the storm as experienced at Worcester, Mass.:

> Even the "oldest inhabitant" admits the ice storm of November 26–29 was the worst that has been known in this section. The ice and sleet which collected on Thanksgiving Day were practically gone when the storm started. Friday was brilliantly clear till late afternoon, and Saturday morning the sky was covered with a thick, snowy, alto-stratus cloud. Snow began to fall at 2 p. m. and continued heavily until 4:45 p. m., when it changed to rain. The temperature of wet surfaces remained below freezing and the rain froze, forming a crust on the snow. Sunday it rained till afternoon, when sleet and moderate rain fell intermittently. The temperature fell to 25° F. in the evening. About 10 p. m. it started to rain steadily. By Monday morning the ice which had formed on the trees was nearly an inch thick on exposed branches and many of the upper ones had broken off and fallen to the ground. The rain continued all day Monday with the rising north-northeast wind, and the temperature just below freezing. By 5 p. m. it was dangerous to walk along the street, so many limbs and wires were falling.
>
> A wild night followed. Sleet rattled and rain pattered and the ice-laden trees creaked continuously. With the passage of each roaring gust, down crashed great branches from trees. The low clouds were intermittently lighted by vivid green flashes from trolley wheels. At daylight a thunderstorm with pink flashes of lightning awakened the people to a scene of sad destruction. Pelting rain and sleet continued to drive by at high speed. The heavy rain which fell Monday night did not freeze as much as that which fell previously, except where the wind was uninterrupted, as the lowest temperature was 28. This water combined with a new fall of 1½ inches of sleet and the previous ice, covered thoroughfares with 5 inches of slush and water. The thunderstorm on Tuesday morning announced the approach of the end. By Tuesday noon there was hardly a tree that had not lost at least one good-sized branch. Ice on exposed ordinary insulated electric wires about one-fourth inch in diameter was more than 2 inches thick, and weighed upward of 1.3 pounds per foot.[1] It was computed that ice on the side of any dense, unbroken evergreen tree 50 feet high and on the average 20 feet wide would have weighed 5 tons. Large crews were kept busy keeping the main thoroughfares cleared of the débris. Telephones, electric lights, telegraphs—everything was out of order. Whole lines of telephone and trolley poles were snapped at the base, crippling both services. For days trolleys did not run in many places and trains were hours late, as the crews had to stop to remove poles from the track. Schools were closed and mail service was badly interrupted. Several people were injured by falling branches and ice, and a number of horses were killed. The damage in Worcester was estimated at several hundred thousand dollars.
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> The total precipitation which fell in the 75½ hours of the storm was 4.05 inches as collected in the rain gage on the roof of the main building, Clark University. Of this, 0.28 was melted snow, and about 1.65 melted sleet. On the following day, bright sunshine soon relieved unbroken branches of some of their load of ice, though not without first inflicting further damage to some trees by expanding the ice on overweighted limbs.
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> The unusual duration of this ice storm seems to have been due to a large supply of cold air flowing southwards, and of warm air going northwards above it. The cold wind at the surface, as is usual when sleet or ice storms occur, formed a barrier over which the warm wind had to rise. It was this rising and the consequent cooling by expansion which reduced the vapor capacity of the wind aloft and thus produced rainfall. The two currents in this case were surprisingly well balanced. The temperature of the lower one did not rise enough above freezing to prevent the continued formation of ice, while the wind above, after the first fall of snow, remained continuously so much above freezing that all the precipitation from it was in the form of rain.
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> It was interesting to note that the conditions which gave the big ice storm here also caused very severe ice storms in Oregon and Washington on November 20 and 21, said to be the worst since 1916, and destroyed thousands of orchard trees.

—*A. J. H.*

ANALYSIS OF SUMMER PRECIPITATION AT MOUNT VERNON, IOWA.

By W. A MOORE and DONALD CORLETT.
[Cornell College, Mt. Vernon, Iowa.]

The following table gives the results of chemical analyses of rains which fell at Mount Vernon, Iowa, during the summer of 1921, in parts per million.

[1] A piece of ice 9.5 inches long, which had fallen from an electric wire on the south side of Coes Pond, was picked up on the morning of Dec. 11. It weighed exactly 1 pound The ice was 1.8 to 2 inches thick and 2.3 to 2.6 inches wide.